Review of the past distribution and decline of the Southern Bell Frog* *Litoria raniformis* in New South Wales

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ABSTRACT

The Southern Bell Frog *Litoria raniformis* was formally widespread throughout south eastern Australia. Poor knowledge of the past and present distribution of populations and the pattern of decline currently limits our ability to plan conservation measures. The past and present distribution of *L. raniformis* in New South Wales (NSW) is described through the use of museum records, wildlife databases, reports and surveys. Survey identified a further 10 populations, all in lower Murrumbidgee floodplain (Lowbidgee), and confirmed the absence of *L. raniformis* in past habitats along the middle reaches of the Murrumbidgee River. Based on past records, *L. raniformis* declines have been substantial. The eastern edge of the geographic range has shifted approximately 500 km west from the South Eastern Highlands, and the northern edge of its range has shifted 200 km south from the most northerly population in Willandra National Park. *Litoria raniformis* is currently restricted to the semi-arid zone of NSW with populations occurring in the Lower Murrumbidgee and Murray River, the Wakool Irrigation Area and the Coleambally Irrigation Area. The wide geographic range of *L. raniformis* prior to the decline means that a single causal factor is unlikely. Former habitats throughout the original range have been highly modified as a result of a range of factors, including flooding regulation, livestock grazing and exotic introductions.

Key words: *Litoria raniformis*, historic distribution, range decline

Introduction

The identification of the extent and timing of a species' decline can yield important clues about the key agents that have acted upon it over time (Caughley and Gunn 1996). To determine these agents, declines need to be measured at spatial and temporal scales large enough to separate natural fluctuations in population numbers from anthropogenic declines (Shaffer *et al.* 1998). In the absence of long-term monitoring programs, determination of the long-term changes in a species' geographic distribution can be achieved through comparisons of past and present records of a species' distribution (Mingozzi and Esteve 1997; Shaffer *et al.* 1998). Records that are suitable for this purpose include natural history collections (Shaffer *et al.* 1998), catch rates (Zwanenburg 2000), bag numbers (Thirgood *et al.* 2000) pelt sales (Jimenez 1996; Riley *et al.* 2004), natural history accounts (Mingozzi and Esteve 1997) or a combination of the above.

A long-term approach to measuring changes in distribution is especially important for amphibian species which often exhibit chaotic population dynamics that are strongly linked to the availability of temporary resources (Blaustein *et al.* 1994; Biek *et al.* 2002). For these species separation of "natural" and anthropogenically driven declines is important, especially when correlations between the decline and the onset of potential causal agents are sought (Kiesecker *et al.* 2001). Natural history collections and literature have been used to determine the status and patterns of declines of riverine frogs (Gillespie and Hines 1999) and the Green and Golden Bell Frog (*Litoria aurea*) (Gillespie 1996; Osborne et al. 1996) in Australia.

Prior to the early 1980's the Southern Bell Frog (*Litoria raniformis*) was considered to be widespread and locally abundant throughout south-eastern Australia and Tasmania (Barker and Grigg 1977). It occupied a range of habitat types including small permanent wetland systems, streams, dams, irrigation areas and large ephemeral wetlands (Mahony 1999).

When local extinctions were first noted in the early 1990's in the South Eastern Highlands of New South Wales (NSW), they were described as sudden, and the actual causes for the declines were poorly understood (Osborne *et al.* 1996). In contrast, declines and local extinctions in Tasmania appeared to occur as a result of wetland degradation, with some declines exacerbated by the 1980's drought (Ashworth 1998).

Declines in the abundance and distribution of *L. raniformis* in South Australia, Victoria and inland areas of NSW have not been formerly documented through dedicated surveys but are thought to be significant (Tyler 1997; Mahony 1999; Pyke 2002). The aim of this review is to describe, in detail the past and present distribution of *L. raniformis* and its habitats in NSW, with special emphasis on records from the Murrumbidgee floodplain and its tributaries in the South West Slopes, Riverina and Murray-Darling Depression biogeographic regions. This review builds on the general national distribution and decline maps of Mahony (1997) and Pyke (2002) using natural history and National Parks and Wildlife

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*Referred to as the Growling Grass Frog in Victoria

Service Atlas database records reports, informal records and field surveys of important wetland systems in the mid and lower Murrumbidgee Floodplain. These included some wetlands where *L. raniformis* had been recorded previously.

Methods

Frog Surveys

Surveys were conducted in wetland systems where *L. raniformis* could potentially occur, or where there were past records. This included the wetlands along the Murrumbidgee River between Wagga Wagga and Balranald, as well as the Coleambally and Murrumbidgee Irrigation Areas. Australian Bureau of Meteorology (BOM) weather records for Coleambally, Narrandera, Hay and Balranald were obtained for the study periods. All surveys were conducted at night during warm conditions, when daytime temperatures exceeded 25°C. A total of 44 sites were surveyed between October 2001 and November 2002 and then again between October 2003 and January 2004.

Due to the size of the study region and the large number of wetlands to be surveyed, a rapid survey approach was adopted. Surveys were conducted after dark, employing a minimum of two 5-minute audio surveys, one 2-minute call playback and two active visual surveys along 100 m transects per 10 hectares of waterbody. Audio surveys involved standing quietly by the waters' edge and listening for calls for 5-minute periods. If no calls were heard, call playback was employed for two minutes followed by a further 5-minute listening period. Active visual searches were conducted along 100-m transects, 1 metre from and parallel to the waters' edge. A 50-watt spotlight was used in a side to side motion to search a 1-metre wide area on either side of the transect and in fringing vegetation.

Road transect surveys were also conducted in the Coleambally Irrigation Area (CIA), the Hay Plain and the Murrumbidgee Irrigation Area because the comprehensive network of roadways allowed transects to be driven between rice bays and along irrigation canals, which are often utilised by *L. raniformis* (AMBS Consulting 2000). This technique involved five minute audio-surveys every 5 km in any area that contained water such as irrigation canals and dams as well as spotlighting along the road edges while travelling at less than 10km/hour.

Historical records

Records for *L. raniformis* voucher specimens collected in NSW between 1900 and 2003 were obtained from the Australian Museum, South Australian Museum, Museum Victoria, and the Australian National Wildlife Collection (CSIRO). The NSW National Parks and Wildlife Services Atlas database records for *L. raniformis* were obtained in October 2003. Information on the present status of *L. raniformis* was obtained from published and unpublished fauna surveys and articles.

The longitude and latitude and easting northing coordinates for each voucher specimen and database record were checked against town and locality information. Where there were discrepancies between map coordinates and location information, the latter was used. Where no map coordinates were supplied, the coordinates of the nearest town were used.

The quality of data ranged from good to very poor with some museum records lacking location data or collection dates these were excluded from further analysis.. There is a single record for *L. raniformis* from Pambula in the South Eastern Corner biogeographic region (Australian Museum Collection) which is outside the accepted range for *L. raniformis* (Mahony 1999). This record has been excluded from consideration because there is a high probability that the specimen has been incorrectly labelled.

Once error checking was complete, the coordinates for all locations where *L. raniformis* had been recorded were imported into a GIS database (ArcMap version 8.3 ESRI). The database also included; NSW rivers, NSW and ACT biogeographic regions (Environment Australia 2000), NSW wetland systems (Environment Australia 2001), NSW state borders, and NSW towns and localities.

Information on the distribution of *L. raniformis* from all data sources was mapped using the revised Interim Biogeographic Regionalisation for Australia (IBRA) (Environment Australia 2000) (hereafter referred to as biogeographic regions). This approach was used for two reasons. Firstly, biogeographic regions more closely reflect the biological and geological character of parts of *L. raniformis'* range than government or topographic units. Secondly, the use of biogeographic regions was considered useful because of the sparse nature of frog records in NSW. This meant that the failure to record *L. raniformis* within individual wetlands where it had occurred previously might occur simply because the area was never re-surveyed or that the results of surveys were not reported. In contrast, the probability of *L. raniformis* being recorded at least once within a whole biogeographic region over a 10-year period is quite high.

There are six biogeographic regions in NSW that occur within the accepted range of *L. raniformis*. These are the South Eastern Highlands, Australian Alps, NSW South Western Slopes, Riverina, Cobar Peneplain and the Murray-Darling Depression.

Results

Survey results

Litoria raniformis was located in two distinctly different wetland types in the Lowbidgee region in the Murray-Darling Depression and western edge of the Riverina biogeographic region. These were River Red Gum (*Eucalyptus camaldulensis*) and Black Box (*E. largiflorens*)/ Lignum (*Muelenbeckia florulenta*). Both River Red Gum and Black Box/Lignum wetlands are normally subject to flooding in 4 out of every 5 years (Kingsford and Thomas 2001).

Litoria raniformis was present on rice growing properties within the CIA, occurring at all 19 sites surveyed. *Litoria raniformis* was not located in any of the wetlands that form part of the Mid Murrumbidgee wetland system.

Description of historic and current distribution

In total, 174 records of *L. raniformis* were obtained from the dedicated surveys, museum records, the NSW NPWS ATLAS database and four reports (Osborne *et al.* 1996; White and Pyke 1999; AMBS Consulting 2000; Wassens 2006). The majority of records were for the Riverina bioregion followed by the South Eastern Highlands. Only four records were from the Cobar Peneplain, which may be a result of the limited surveys conducted in this region (Table 1).

Based on the combination of known past and present habitats occupied by *L. raniformis* in NSW, declines occurred almost simultaneously in the northern and eastern parts of the species' geographic range (Table 1). As a result of these local extinctions, the eastern edge of the geographic range of *L. raniformis* has shifted approximately 500 km west from the South Eastern Highlands, and the northern edge of its range has shifted 200 km south from the most northerly population in Willandra National Park.

South Eastern Highlands and Australian Alps

The most northerly records of *L. raniformis* are from the South Eastern Highlands near Bathurst west of the Great Dividing Range (Fig. 1). *Litoria raniformis* was recorded at a number of wetlands this region during the 1970's but was locally extinct by the 1980's (Ehmann and White 1997). *Litoria raniformis* was also formerly widespread in the southern part of the South Eastern Highlands (Osborne *et al.* 1996). Prior to 1980 it was considered to be relatively common in the ACT, occurring in natural wetlands such as Lake George near Collector and artificial wetlands in Canberra including Lake Ginninderra and Lake Burley Griffin (Osborne *et al.* 1996). Further south, *L. raniformis* was recorded on multiple occasions near Cooma and Nimmitabel prior to 1979. In the extreme south of the biogeographic region, *L. raniformis* was recorded from the Monaro Lakes near Bombala on 11 separate occasions between 1955 and 1980 (Australian Museum Collection). These wetlands are a series of permanent and ephemeral upland wetlands ranging in size from 0.5 to 215 ha (Australian Nature Conservation Agency 1996). On the western side of the Australian Alps *L. raniformis* was recorded around Talbingo until 1980 and near Khancoban in the early 1970's.

There is some disagreement as to whether *L. raniformis* remains in the Monaro region at the southern end of the South Eastern Highlands. Mahony (1999) notes that *L. raniformis* was present in the area in the 1990's, however surveys of this region in the late 1990's failed to locate *L. raniformis* (Osborne, pers. com. 2004).

South West Slopes

Litoria raniformis appears to have been widespread throughout the South Western Slopes of NSW, particularly along the Murrumbidgee and Murray River systems and their tributaries until the early 1980's. However, due to the limited records and small number of frog surveys conducted, it is difficult to determine exactly when local extinctions occurred after this. Jansen and Healey (2003) surveyed wetlands along the Murrumbidgee River, including historical *L. raniformis* habitats such as Berry Jerry Lagoon and the Mid Murrumbidgee Wetlands, from Gundagai in the east of the Southern Western Slopes Biogeographic region to Hay in the Riverina Biogeographic region, and failed to locate *L. raniformis*. Surveys of wetlands along the Murrumbidgee tributaries in the South West Slopes between 2002 and 2004, including Buckingbong State Forest and Medium Swamp where *L. raniformis* had been recorded previously, also failed to locate it (Leigh Thompson, Johnstone Centre Environmental Consulting, pers. com.).

The status of populations of *L. raniformis* along the Murray River in the South West Slopes is uncertain. It appears to have been quite widespread in wetlands around Woomargama National Park, near Albury (Caughley and Gall 1985), but there have been no confirmed records of this species from this area since 1979. There is also an unconfirmed record of *L. raniformis* occurring in the Wonga wetlands near Albury in 1999 (NPWS, 2003) but the accuracy of this record is questionable (Matt Herring, Charles Sturt University, pers. com.).

Cobar Peneplain

Litoria raniformis was first collected from the Cobar Peneplain biogeographic region in Willandra National Park near Hillston in 1928 (Australian Museum Collection) and again in 1985 (NPWS, 2003). Within Willandra National Park *L. raniformis* is likely to have occurred in the Willandra Creek and ephemeral wetlands associated with Willandra and Yangellawah Creeks, which are distributaries of the Lachlan River. *Litoria raniformis* was

Table 1. Number of *L. raniformis* records, including new data collected during the surveys, in each biogeographic region in NSW and the ACT during each decade since 1900.

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	total
Australian Alps	1					1	1	4				**7**
South Eastern Highlands	1					2	10	17	16			**46**
Cobar peneplain			1					2	1			**4**
South West Slopes				1			4	16	1	1		**23**
Riverina				3		4	11	13	1	9	18	**59**
Murray-Darling Depression						3	1	2	2	15	9	**32**
Total NSW & ACT	**2**	**0**	**1**	**4**		**10**	**29**	**59**	**22**	**25**	**27**	**171**

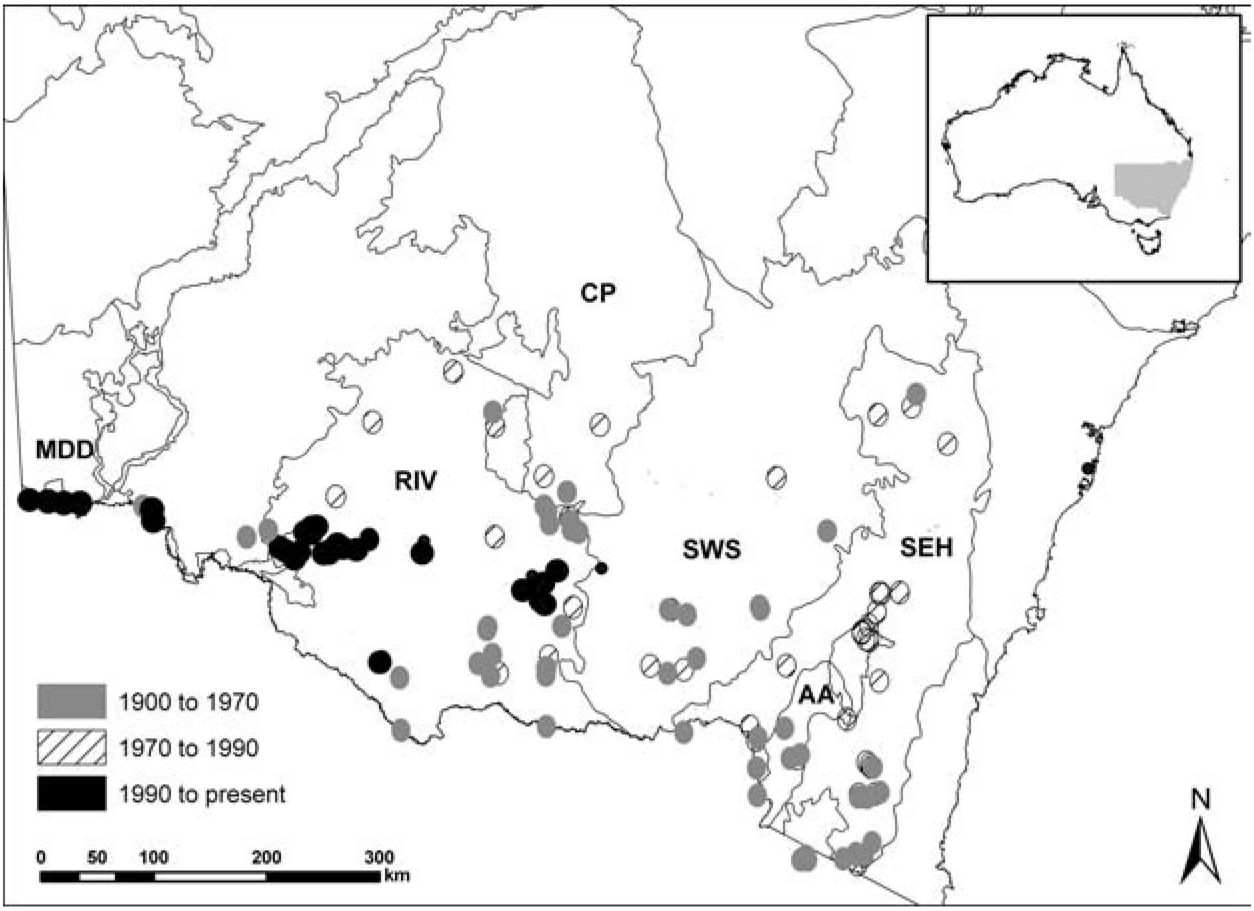

Figure 1. The distribution of *L. raniformis* populations over 20 year time intervals in each biogeographic region: AA Australian Alps, SEH South eastern Highlands, SWS South West Slopes, RIV Riverina, MDD Murray –Darling Depression.

last recorded in Willandra National Park in 1985 and has not been recorded since, despite surveys by students from the University of Canberra (Dr Will Osborne, University of Canberra, pers. com.). Willandra Creek, which is the main waterway in the park, is presently subject to flow regulation and contains water in all but severe drought conditions (New South Wales National Parks and Wildlife Service 1989). The Willandra National Park 1989 management plan does not mention *L. raniformis* or potential habitats (New South Wales National Parks and Wildlife Service 1989). There are a number of records from the southern edge of this region, mainly from wetland systems west of Murrami (Museum Victoria).

Riverina

Litoria raniformis was widespread throughout the Riverina biogeographic region and individuals still persist in wetlands along the lower Murrumbidgee and Murray Rivers (NPWS, 2003). However, declines have been extensive from other parts of the Riverina biogeographic region, in the north *L. raniformis* occurred in wetland systems off the Lachlan River. It was recorded from the Booligal wetlands in 1978 (Australian National Wildlife Collection) and Wooran near Booligal in 1980 (Australian Museum Collection). *Litoria raniformis* probably went locally extinct from wetlands around Booligal in the early 1980's after the ephemeral wetlands that were present after the 1974 floods dried up. It was also recorded near Oxley in 1972 and Hill End in 1961 (Museum Victoria) but has not been recorded since. In the south east, *L. raniformis* was found at Barron Box Swamp near Griffith in 1967, which at this time was a large ephemeral wetland system (Australian National Wildlife Collection). This wetland was surveyed in 2003 along with all other major wetland systems in the Murrumbidgee Irrigation Area, but no *L. raniformis* individuals were located (Wassens 2006). Barron Box Swamp was converted for use as permanent water storage in the late 1970's (Briggs *et al.* 1997). In the middle reaches of the Murrumbidgee River, *L. raniformis* was collected from oxbow lagoons between Narrandera and Darlington Point between 1957 and 1979. These sites included the mid Murrumbidgee wetlands, Yanco Agricultural High School wetlands and Darlington Point wetlands (Australian Museum Collection; South Australia Museum). Jansen and Healey (2003) surveyed historical *L. raniformis* sites between Narrandera and Hay, including Darlington Point wetlands, and did not locate any individuals of this species.

Litoria raniformis populations persist in the Coleambally Irrigation Area (CIA) south of the Murrumbidgee (AMBS Consulting 2000), where it was first recorded in 1932. Given that the CIA was not developed until the late 1960's, it is difficult to determine whether these are founder populations from the Murrumbidgee floodplain or represent an expansion of populations that may have existed along Coleambally Creek (now the CIA outfall drain) and Buckingbong State Forest (Caughley and Gall 1985).

Litoria raniformis persisted in the Murrumbidgee Irrigation Area (MIA) immediately north of Murrumbidgee River in the Riverina biogeographic region until the early 1980's (National Museum Collection), but has since disappeared (Wassens 2006).

Litoria raniformis occurred in River Red Gum wetland systems on the Murray River in the Riverina Biogeographic region, and was recorded in the Mulwala and Boomanoomana State Forests in 1979 (Caughley and Gall 1985), and the Barmah-Millewa State forest in 1959 and 1963 (Victoria Museum). The status of *L. raniformis* populations in these wetland systems is uncertain as surveys have been very limited. However, recent frog surveys of the Barmah-Millewa Forest in 2003-2004 did not record *L. raniformis* (Ward 2004), and the lack of any records since 1979 suggests that local extinction may have also occurred in the Mulwala and Boomanoomana State Forests. In the extreme west of the Riverina biogeographic region, *L. raniformis* persists in wetlands near the confluence of the Murray and Rufus Rivers, possibly in Lake Victoria (NPWS).

Litoria raniformis populations also persist in the Wakool region, north of the Murray River within both irrigation infrastructure and natural Black Box wetlands (Matthew Herring, Charles Sturt University, pers. com.). Formal frog surveys of the Murray River and associated wetlands have been limited; however, Matthew Herring conducted general fauna surveys at 94 wetlands in Northern Victoria and the NSW Murray Catchments and failed to detect *L. raniformis* (Matthew Herring, Charles Sturt University, pers. com.). In addition, the Heartlands Eastern Billabong Wildlife Survey conducted around Henty in 2000-2001 also failed to detect *L. raniformis* (Matt Herring, Charles Sturt University, pers.com.)

Murray-Darling depression

Records from the Murray-Darling Depression are limited but this may be a result of poor survey effort; *Litoria raniformis* remains locally abundant in the Lowbidgee region at the confluence of the Murray and Darling Rivers and down stream along the Murray River into South Australia (NPWS database).

Conclusion

Litoria raniformis formerly occurred across a large area, occupying a diverse range of habitats from alpine streams to ephemeral wetlands in the semi-arid zone (Pyke 2002).Given the widespread nature of declines and the range of habitats affected, a number of different threatening processes are likely to have contributed to declines in different areas. These differences are especially evident when considering differences in declines between populations in the South Eastern Highlands and riverine populations in the South West Slopes. Declines of the populations in the South Eastern Highlands did not coincide with significant changes in wetland condition (Osborne *et al.* 1996). In contrast, former habitats within the South West Slopes have been highly modified, either through their conversion permanent water storages or through reduced flooding frequency as result of flow regulation (Briggs *et al.* 1997; Jansen and Robertson 2001). In the former case, an outbreak of Chytrid is likely to have played a significant role in local extinctions of *L. raniformis* (Osborne *et al.* 1996). However, there is little evidence that chytrid contributed to declines in the inland regions of NSW because the disease is much less likely to be present in areas with higher mean temperatures (Woodhams *et al.* 2003).

Gambusia has been shown to prey heavily on *L. aurea* eggs and small tadpoles in tank experiments (Morgan and Buttemer 1996; Pyke and White 2000).Predation of tadpoles by the introduced fish Gambusia (*Gambusia holbrooki*) has been implicated in the declines of a number of frog species in Australia, including *L. raniformis* (Morgan and Buttemer 1996; Pyke and White 2000). However, in natural environments viable *L. raniformis* populations commonly persist with relatively high Gambusia densities (Osborne *et al.* 1996; Ashworth 1998; Heard et al. 2004). The apparent contradiction between tank experiments and field studies probably occurs because of the strong interaction between predation rates by Gambusia, aquatic vegetation cover and wetland permanence. Periodic drying reduces fish densities in wetlands (Baber *et al.* 2002), while predation rates may increase with reduced aquatic vegetation cover (Lawler *et al.* 1999). Because of this, the impact of Gambusia needs to be considered in conjunction with other factors, particularly wetland degradation and hydrological changes.

Limitations of the data

The use of historical records to describe patterns of declines has a number of limitations. Firstly, records of *L. raniformis* in inland NSW are limited and have usually been conducted at a single point in time. In many cases poor survey repetition makes it difficult to accurately place the declines within a particular decade. In addition, some of the wetlands where *L. raniformis* once occurred have not been resurveyed. In cases where *L. raniformis* populations were small, they could have been overlooked during surveys, as was the case for a *L. aurea* population south of Queanbeyan (Wassens and Mullins 2001).

A second problem with the use of historic records is the lack of habitat data. The habitat requirements of *L. raniformis* populations in inland NSW outside of irrigation areas have received little attention and it is unclear how populations might have responded to changes in wetland condition as a result of flow regulation and cattle grazing. In addition, it is not clear when these habitat changes occurred in particular wetlands, whether they coincided with *L. raniformis* declines, and if they did, whether these changes were causal or coincidental to the declines. Great care must be taken when interpreting the timing of decline, particularly on the basis of limited data, because the last recorded populations and extinctions are likely to represent the end point of a protracted decline period marked by local extinctions of smaller populations (Hobbs and Mooney 1998) rather then a single catastrophic event occurring over a short time frame.

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